Europa Orbiter Mission Design Overview

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The Europa Orbiter mission, one of three missions in NASA's Outer Planets Program, will place a spacecraft into orbit about Europa to determine the presence or absence of a liquid ocean on Europa. In previous work[i,ii] we have demonstrated the existence of integrated trajectories, which use a direct transfer from Earth to Jupiter, a nearly ballistic Galileo-like tour to reduce perijove and period, and a series of nearly resonant encounters with Europa. These Europa encounters, combined with perijove-raising maneuvers and third-body perturbations from Jupiter, further reduce the orbital period and lead to an elliptic approach with respect to Europa just prior to orbit insertion. In this paper, we discuss how constraints of solar conjunction and Earth range affect the launch/arrival space, how restricting the number of arrival dates affects ΔV performance, and how low-radiation, low-ΔV tours with the desired orbit orientation are achievable through judicious tour design. Alternate interplanetary trajectory options (direct trajectories for later launch years as well as indirect trajectories utilizing gravity assist flybys of Venus, Mars, and/or Earth) are also discussed.

The Europa Orbiter mission phases consist of the launch, interplanetary trajectory, Jupiter arrival (which includes a gravity-assist flyby prior to initial perijove passage, the orbit insertion burn, initial orbit and any perijove raise maneuver needed), a nearly ballistic satellite tour using Ganymede, Callisto and Europa to reduce period, the "endgame" (consisting of nearly resonant Europa encounters, perijove-raising maneuvers at apojove to reduce the V_∞ at Europa encounter, and the orbit insertion maneuver to place the spacecraft into orbit about Europa), and a 30-day orbital phase.

Current plans call for the Europa Orbiter (EO) spacecraft to launch in November 2003 on a direct trajectory to Jupiter. An Atlas V or Delta IV launch vehicle with a Star 48V upper stage will inject the 1600 kg Europa Orbiter. A 14 day launch period is possible for a launch energy $C_3 = 80\ km^2/s^2$. Several non-direct trajectories, including a 3yr ΔV-EGA (Delta-V Earth-Gravity-Assist), MEGA (Mars-Earth-Gravity-Assist), and VEEGA (Venus-Earth-Earth-Gravity-Assist) have been examined. These alternate trajectories allow the potential of using STS/IUS, Delta 3, or Atlas 3 launch vehicles.

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The Science Definition Team for Europa Orbiter has identified a strawman set of instruments that meet the primary objectives of the mission. These instruments include a spacecraft transponder for tracking, a laser altimeter, ice penetrating radar sounder and imaging instruments. The selection of the science teams and instruments is expected to be made in the spring of 2000. An initial assessment of the implications of that selection on the mission design will be discussed.

The current radiation design requirement is that the Europa Orbiter spacecraft must be able to withstand a 4 Mrad dose (as evaluated behind 100 mils aluminum). Integrated trajectories selected for detailed evaluation of radiation dosage all meet the <4 Mrad dosage requirement. As expected, reducing the number of perijove passages and maintaining higher perijove ranges are the key factors in lowering overall radiation dosage. Further work in this area is expected to yield additional dose reduction.

In addition to radiation dosage, another primary consideration in the trajectory design is minimizing the ΔV expenditure to accomplish the mission objectives. Through the use of additional Ganymede flybys to extend the satellite tour design (ballistic) phase, the orbital period can be reduced without the need for as many perijove-raising maneuvers at apojove in the "endgame" phase. The current ΔV allocation is 2300 m/s, which breaks down into 1000 m/s for the combination of broken plane, Jupiter orbit insertion and perijove raise maneuvers, 750 m/s for the combination of tour, endgame and Europa orbit insertion maneuvers, about 250 m/s for navigation and statistical ΔV, and about 300 m/s for various liens. The most significant liens are related to providing a telecom link at EOI, potential altitude changes for science purposes and at end of mission to increase the orbit lifetime, and orbit orientation issues pertaining to lighting conditions during the 30 day Europa orbital phase.

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[i] J. M. Ludwinski, M. D. Guman, J. R. Johannesen, R. T. Mitchell, and R. L. Staehle, "The Europa Orbiter Mission Design," IAF 98-Q.2.02, 49th International Astronautical Congress, Sept. 28-Oct. 2, 1998, Melbourne, Australia.

[ii] J. R. Johannesen and L. A. D'Amario, "Europa Orbiter Mission Trajectory Design," AAS 99-360, AAS/AIAA Astrodynamics Specialist Conference, Aug. 16-19, 1999, Girdwood, Alaska.